Solar Power Remote Monitoring and Controlling Using IOT

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Abstract**—** The Internet of Things (IoT) has a vision in which the internet extends into the real world, which incorporates everyday objects. Solar power remote monitoring and controlling using IoT is to monitor and control the power in the solar panels from anywhere in the world. Using the Internet of Things Technology for supervising solar photovoltaic power generation can greatly enhance the performance, monitoring and maintenance of the plant. With advancement of technologies the cost of renewable energy equipment's is going down globally encouraging large scale solar or photovoltaic installations. The solar tracking is used to increase the power consumption according to sun direction. The influence of contact thermal resistances is evaluated by the Open-Circuit Voltage (OCV) method used for the Maximum Power Point Tracking (MPPT).

Keywords**—** *Internet of Things; Solar power; environmental monitoring system; photovoltaic installations; Open-Circuit Voltage; Maximum Power Point Tracking. renewable energy.*

I. INTRODUCTION

With advancement of wired and wireless network technologies, internet- connected mobile devices such as smart phones and tablets are now in widespread use. Thus resulting in a new concept, Internet of Things (IoT) was introduced and has received attention over the past few years. In general, IoT is actually an information sharing environment where objects in every-day life are connected to wired and wireless networks. Recently, it is used not only for the field of consumer electronics and appliances but also in other various fields such as a smart city, healthcare, smart home, smart car, energy system, and industrial security.

At present, the solar photovoltaic (PV) energy is one of the pivotal renewable energy sources. The solar energy is becoming a potential solution towards sustainable energy supply in future. As more and more Rooftop Solar Photovoltaic systems are getting integrated into the existing grid, there is a growing need for monitoring of real time generation data obtained from solar photovoltaic plants so as to optimize the overall performance of the solar power plant and to maintain the grid stability. As local monitoring is not possible for the installer therefore monitoring remotely is essential for every solar power plant. Power generation from Solar Photovoltaic plants is variable in nature due to changes in solar irradiance, temperature and other factors. Thus remote monitoring is essential. For developing remote monitoring system for solar photovoltaic Power plant, IoT (Internet of Things) approach is taken in this work which actually envisions a near future where everyday objects will be armed with microcontrollers and transceivers for digital communication.

The remote monitoring eliminate the hazards associated with the traditional wiring systems and make data measurement and monitoring process much easier and cost effective and IoT based systems take a giant leap towards monitoring by intelligent decision making from web. The decentralized architecture of the remote monitoring systems and its flexibility of deployment make it most suitable for industrial purposes.

In general remote monitoring systems have to fetch, analyses, transmit, manage and feedback the remote information, by utilizing the most advanced science and technology field of communication technology and other areas. It also merges comprehensive usage of instrumentation, electronic technology and computer software. Prevalent monitoring PV system approaches present poses some problems like low automaticity and poor real-time. These problems can be averted with an efficient remote environment information monitoring and controlling system. This system should include automatic diagnosis techniques the PV station.

A. Communicating With The System: Technology

Wi-Fi technology is also used for remote monitoring and control of PV system for domestic applications. Wi-Fi (IEEE 802.11g) is chosen as it operates at 2.4GHz and offer high data rate of about 54Mbps in contrast to ZigBee (250Kbps). But this solution is suitable for micro grid network architecture. A predictive maintenance which includes localization and definition of related faults and failures in a PV system is very important. In what follows, concentration has been given on the most widely used ones. Remote monitoring and control of PV system based on ZigBee technology is inefficient in large scale because it can't face up huge distance.

Another wire-based possibility is via the grid, with the power cables being modulated with the data. Wi-Fi technology is also used for remote monitoring and control of PV system for domestic applications. Wi-Fi (IEEE 802.11g) is chosen as it operates at 2.4GHz and offer high data rate of about 54Mbps in contrast to ZigBee (250Kbps). But this solution is suitable for micro grid network architecture.

II. EXISTING SYSTEM

At present, a number of PV monitoring system has been put into operation. These systems often use wireless public networks such as GSM or other wireless communication networks for data transmission. But there are problems of high operation and maintenance cost which restrict the development of monitoring system and ultimately hinder the process of efficient generation monitoring in real time. This has influenced us to investigate a novel remote monitoring and control of PV system based on IoT.

The experimental set up includes solar panels, temperature sensor LM35, voltage transducers, current transducers, SIM900A GPRS module, PIC16F877A microcontroller, RS232 interfaces and converters. Programming Codes developed in house are run in Proteus software and hex code is loaded using MPLAB software. The visualization of the collected data in the control station has been done using website designed. A microcontroller is a computer present in a single integrated circuit which is dedicated to perform one task and execute one specific application. It contains memory programmable input/output peripherals as well as processor.PIC (Peripheral Interface Controller) is a family of specialized microcontroller chips produced by Microchip Technology in Chandler, Arizona. Key features include wide availability, low cost, ease of reprogramming with built-in EEPROM (electrically erasable programmable read-only memory), an extensive collection of free application notes, abundant development tools, and a great deal of information available on the Internet. The PIC microcontrollers appeal to hobbyists and experimenters, especially in the fields of electronics and robotics.

A ZigBee is an open global standard for wireless technology designed to use low-power digital radio signals for personal area networks. ZigBee operates on the IEEE 802.15.4 specification and is used to create networks that require a low data transfer rate, energy efficiency and secure networking. It is employed in a number of applications such as building automation systems, heating and cooling control and in medical devices.

General Packet Radio Services (GPRS) is a packet based wireless communication service that promises data rates from 56 up to 114 Kbps and continuous connection to the Internet for mobile phone and computer users. The higher data rates allow users to take part in video conferences and interact with multimedia Web sites and similar applications using mobile handheld devices as well as notebook computers. GPRS is based on Global System for Mobile (GSM) communication and complements existing services such circuit-switched cellular phone connections and the Short Message Service (SMS).

A Solar Tracker is a device onto which solar panels are built-in which tracks the motion of the sun ensuring that maximum amount of sunlight strikes the panels all over the day. Power output from a solar cell will be maximum when it is facing the sun i.e. the angle between its surface and sun rays is 90 degree. Solar tracking allows more energy to be produced because the solar array is able to remain aligned to the sun. The components used for its construction are servo motor, Arduino and LDR. The active sensors continuously monitor the sunlight and alternate the panel towards the direction where the intensity of sunlight is maximum. In this project, it’s divided by two categories; hardware and software. In hardware part, 2 light dependent resistor (LDR) has been used to trace the synchronize of sunlight by detecting brightness level of sunlight. For rotation part, one standard servo motor has been selected. In software part, the code is constructed in C programming and inserted in Arduino. This project is designed for low power and portable application. Therefore, it’s suitable for rural area usage. Moreover, the effectiveness of output power which collected by sunlight are increased [2]. The main purposes of a monitoring system are to measure the energy yield, to assess the PV system performance and to quickly identify design flaws or malfunctions. Many large PV systems use analytical monitoring to prevent economic losses due to operational problems. As specified by the requirements for analytical or detailed monitoring include an automatic dedicated data acquisition system with a minimum set of parameters to be monitored. A study of failures for grid-connected residential PV systems of 1-5 KWP installed in Germany in the 1990’s found that a statistical failure happened every 4.5 years per plant. Inverters contributed 63%, PV modules 15% and other system components 22% to the total failures [3].

The wireless remote monitoring system has more and more application, a remote monitoring system based on SMS of GSM is presented. In this system, GSM network is a medium for transmitting the remote signal. The system includes two parts which are the monitoring center and the remote monitoring station. The monitoring center consists of a computer and a TC35 communication module of GSM. The computer and TC35 are connected by RS232. The remote monitoring station includes a TC35 communication module of GSM, a MSP430F149 MCU, a display unit, various sensors, data gathering and processing unit. The remote communication between the monitoring center and the remote monitoring station, and the remote monitoring function is realized [4]. This enables the synthesis of a SCADA (supervisory control and data acquisition) system, named Pollution Guard, designed to collect and process atmospheric pollution data measured in several strategic points of a region. Pollution Guard makes use of the GPRS (general packet radio service) data communication infrastructure from a mobile communication provider that covers a very large area, practically the air pollution data being collected from every place in the country. In comparison to other similar systems, the new functionalities provided by Pollution Guard are the SMS (short messaging system) and e-mail alerts generated when the level of toxic substances exceeds some given values, chosen with regard to respiratory illness [5]. This proposes a wireless Automation system for minimum human intervention industrial critical process, in which automation of process control need to be remotely monitored and reconfigured by the plant operator using GSM/ SMS communication. The system proposed here makes Automation process more flexible by having an option for the operator to take runtime decision to override the set values in Automation. The system uses GSM/SMS between the Automation Process and the Operator thereby extending the mobility of the operator. This system utilizes the Analog sensors, STM32V ARM development board with SD Card and GSM900 a Modem with GPRS activated. An SD card linked with the STM32V enables logging and uploading of plant parameters in a server for later reference and study. Thus a ubiquitous system using GSM and GPRS based Web

Technology is suggested for continuous monitoring and control of Industrial process. [6].

III. PROPOSED SYSTEM

The proposed conceptual system in this work is to monitor the state of a photovoltaic system through an IoT based network in order to control it remotely. The information from the sensors is transmitted via the mobile radio network. A GPRS module is employed to send data to the remote server.

A. IOT Application for Solar Power Sector

IoT application schematic for the Solar Power Plant is shown in figure 1. The schematic diagram is three layered starting with the sensing layer at bottom which comprises of current sensors, voltage sensors, pyrometer for irradiance measurement and other sensors, this layer also includes microcontroller based data processing of data acquired from the sensors. The microcontroller communicates with wireless module to initiate and transmit data to server. Layer 2 as envisaged is the network layer where data logging from the plant for real time processing is done which includes database for storage. Then after the network layer, this processed and stored data is used in the application layer. In this layer sophisticated web based services are designed based on the data collected, processed and stored. Graphical user interfaces will help to monitor the performance of the plant, console will also advice the administrator with decision based on historical data that will significantly reduce the decision making time. By using the IoT based remote monitoring system it will be easier to supervise the overall performance of a solar power plant by a web based approach.

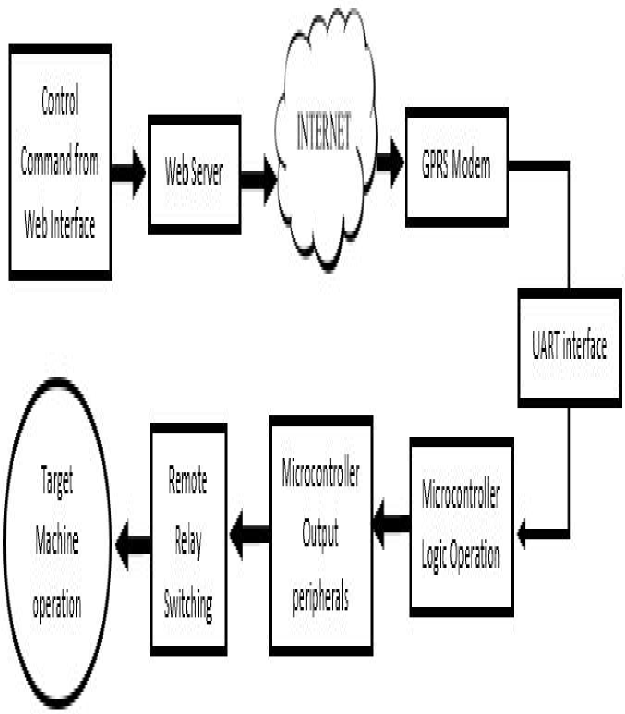

Fig 1: Proposed system block diagram

PIC is a family of Harvard architecture microcontrollers made by Microchip Technology, derived from the PIC1640. Originally developed by General Instrument's Microelectronics Division. The name PIC initially referred to "Programmable Interface Controller".PICs are popular with both industrial developers and hobbyists alike due to their low cost, wide availability, large user base, extensive collection of application notes, availability of low cost or free development tools, and serial programming (and re-programming with flash memory) capability. PIC16f877a finds its applications in a huge number of devices. It is used in remote sensors, security and safety devices, home automation and in many industrial instruments. An EEPROM is also featured in it which makes it possible to store some of the information permanently like transmitter codes and receiver frequencies and some other related data. The cost of this controller is low and its handling is also easy. It's flexible and can be used in areas where microcontrollers have never been used before as in coprocessor applications and timer functions etc.

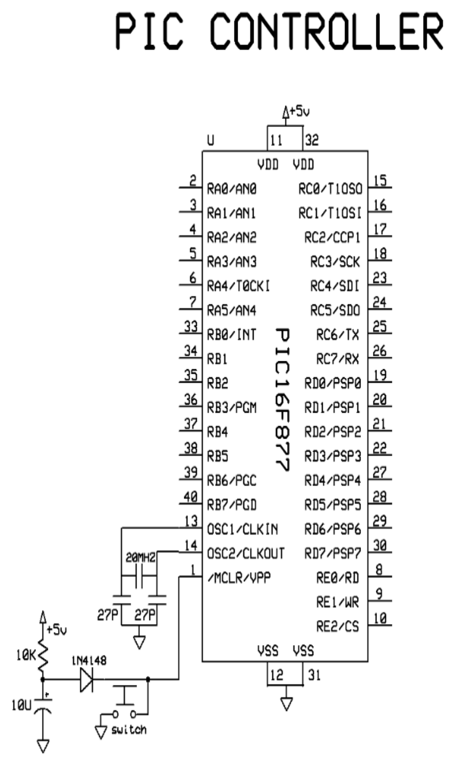

Fig: 2; Pin Diagram for PIC16F877

A. Data Space (RAM)

PICs have a set of registers that function as general purpose RAM. Special purpose control registers for on-chip hardware resources are also mapped into the data space. The addressability of memory varies depending on device series, and all PIC devices have some banking mechanism to extend addressing to additional memory.

B. Code Space

The code space is generally implemented as ROM, EPROM or flash ROM. In general, external code memory is not directly addressable due to the lack of an external memory interface. The exceptions are PIC17 and select high pin count PIC18 devices.

C. Word Size

The word size of PICs can be a source of confusion. All PICs handle (and address) data in 8-bit chunks, so they should be called 8-bit microcontrollers. However, the unit of addressability of the code space is not generally the same as the data space. For example, PICs in the baseline and mid-range families have program memory addressable in the same word size as the instruction width, i.e. 12 or 14 bits respectively.

D. Stacks

PICs have a hardware call stack, which is used to save return addresses. The hardware stack is not software accessible on earlier devices, but this changed with the 18 series devices. Hardware support for a general purpose parameter stack was lacking in early series, but this greatly improved in the 18 series, making the 18 series architecture friendlier to high level language compilers.

III. SYSTEM REQUIREMENTS AND RESULTS

A. MPPT METHOD [MAXIMUM POWER POINT TRACKING METHOD]

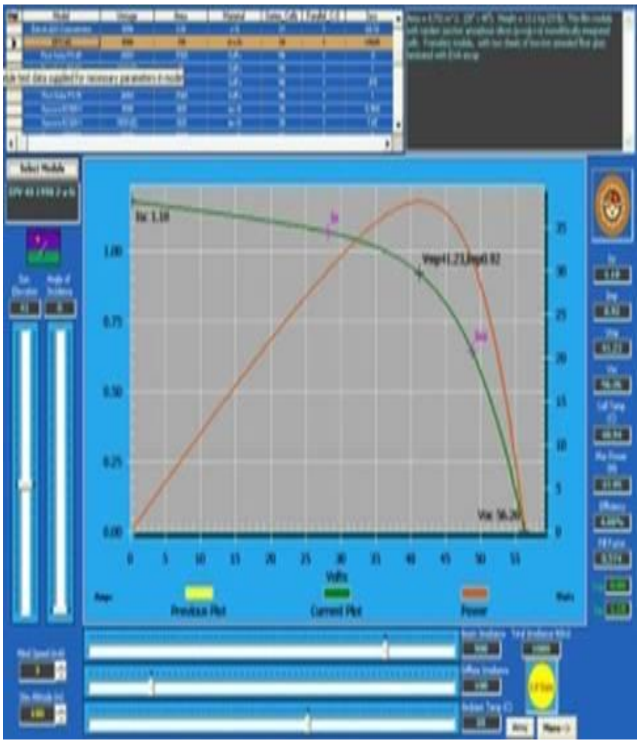

Fig 3; The I-V curves show maximum power from PV modules

MPPT or Maximum Power Point Tracking is algorithm that included in charge controllers used for extracting maximum available power from PV module under certain conditions. The voltage at which PV module can produce maximum power is called 'maximum power point' (or peak power voltage). Maximum power varies with solar radiation, ambient temperature and solar cell temperature. Typical PV module produces power with maximum power voltage of around 17 V when measured at a cell temperature of 25°C, it can drop to around 15 V on a very hot day and it can also rise to 18 V on a very cold day.

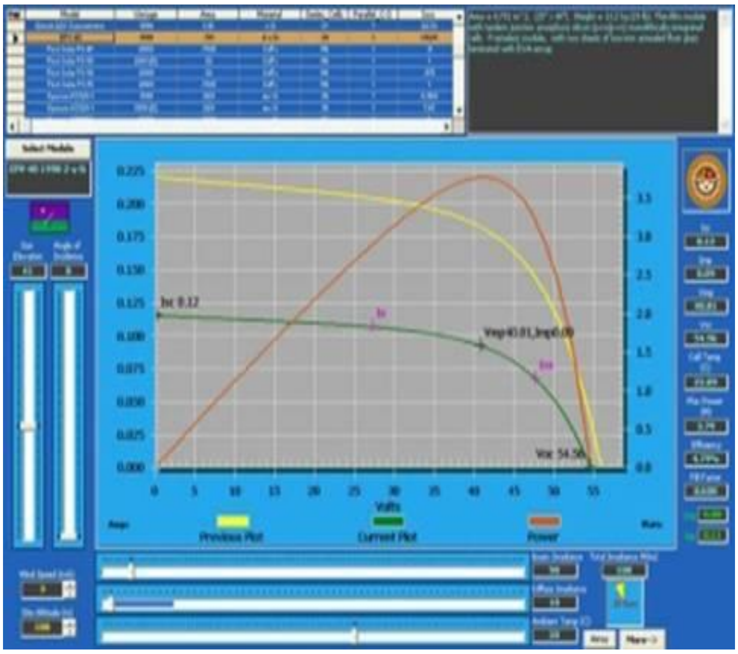

Fig 4; The I-V curves show maximum power from PV modules when exposed to irradiance 100 W/m2

The functional and non-functional requirements for the system are described in this chapter. The overall description of the software used in the implementation of the system is given.

B. MPLAB IDE

MPLAB is a Windows program package that makes writing and developing a program easier. It could best be described as developing environment for a standard program language that is intended for programming a PC. Some operations which were done from the instruction line with a large number of parameters until the discovery of IDE "Integrated Development Environment" are now made easier by using the MPLAB.MPLAB consists of several parts:

Fig.5; MPLAB IDE

Embedded C

Embedded C, even if it's similar to C, and embedded languages in general requires a different kind of thought process to use. Embedded systems, like cameras or TV boxes, are simple computers that are designed to perform a single specific task. They are also designed to be efficient and cheap when performing their task. For example, they aren't supposed to use a lot of power to operate and they are supposed to be as cheap as possible. As an embedded system programmer, you will have simple hardware to work with. You will have very little RAM, ROM and very little processing power and stack space. Your goal is to write programs that are able to leverage this limited processing power for maximum effect. As an ordinary C programmer, you don't have as many constraints .Embedded C programming plays a key role in performing specific function by the processor. In day-to-day life we used many electronic devices such as mobile phone, washing machine, digital camera, etc. Let's see the block diagram representation of embedded system programming.

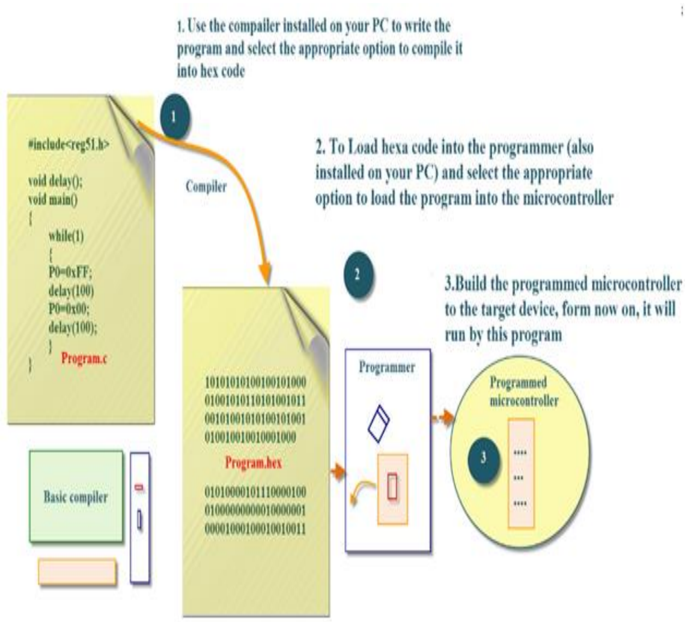

Fig.5; MPLAB IDE with embedded interfacing

C. Proteus Design Suite

The Proteus Design Suite is a proprietary software tool suite used primarily for electronic design automation. The software is used mainly by electronic design engineers and technicians to create schematics and electronic prints for manufacturing printed circuit boards.

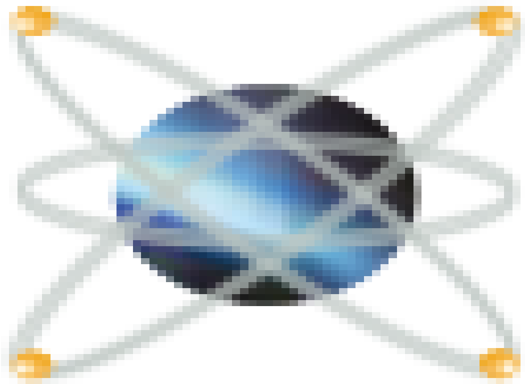

Fig 6 ; PROTEUS 8

The micro-controller simulation in Proteus works by applying either a hex file or a debug file to the microcontroller part on the schematic. It is then co-simulated along with any analog and digital electronics connected to it. This enables its use in a broad spectrum of project prototyping in areas such as motor control, temperature control and user interface design.

IV. CONCLUSION AND FUTURE SCOPE

Utilization of IoT for monitoring of a solar power plant is a vital step as day by day renewable energy sources are getting incorporated into utility grid. Thus automation and intellectualization of solar power plant monitoring will intensify future decision making process for large scale solar power plant and grid integration of such plants. In this paper we suggested an IoT based remote monitoring system for solar power plant, the approach is studied, implemented and successfully attained. The remote transmission of data to a server for management. IoT based remote monitoring will upgrade energy effectiveness of the system by making use of low power consuming advanced wireless modules thereby decreasing the carbon foot print. Web Console based interface will reduce time of manual monitoring and aid in the process of scheming task of plant management. A provision of advance remotely manage the Solar PV plants of various operations like remote shutdown, remote management is to be integrated with this system later. Solar is the fastest-growing renewable energy source in the world, increasing in worldwide capacity by an average of 40 percent every year. Many energy companies are expanding to offer solar, which is among the most energy-efficient and lucrative sources of renewable electricity on the market. Today, solar energy companies have more options than ever before for making the most out of their equipment. Harnessing the power of the IoT can resolve common challenges associated with complex energy grids and make it far easier to manage panels and energy output. For solar energy companies, installing an IoT system will help meet customers' demands and improve overall efficiency. While it has many advantages, solar power can be a challenge for energy companies when it comes to management. To start, you need to connect solar panels to the utility grid. You also need to ensure that your cellular modules, gateways and web platforms are all integrated properly, without breaks in connectivity.

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